

(10) **Patent No.:** US 9,225,223 B2  
(45) **Date of Patent:** Dec. 29, 2015

(2006.01)

(2006.01)

(52) **U.S. Cl.**  
CPC ..... ***H02K 7/145*** (2013.01); ***H02K 3/522***  
(2013.01); ***H02K 11/0073*** (2013.01); ***H02K***  
***29/08*** (2013.01)

(58) **Field of Classification Search**  
USPC ..... 310/50, 71, 68 B, 413-415  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,910,420	A *	3/1990	Hoover et al. ....	310/68 B
5,877,574	A *	3/1999	Molnar .....	310/215
5,895,994	A *	4/1999	Molnar et al. ....	310/215
2005/0212367	A1 *	9/2005	Blase et al. ....	310/68 B
2010/0109458	A1 *	5/2010	Hauser et al. ....	310/71

\* cited by examiner

Primary Examiner — Thanh Lam

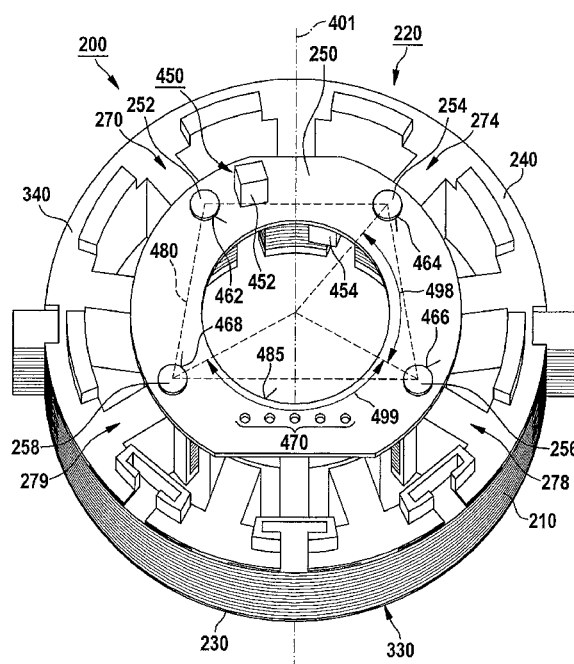
(74) *Attorney, Agent, or Firm* — Kenyon & Kenyon LLP

(57) **ABSTRACT**

In a power tool having an electronically commutated drive motor to which stator components are assigned, which stator components have a stator core equipped with an insulating body, a positioning unit is provided on the insulating body. The positioning unit is designed to enable a positioning of a circuit board, which is assigned to the drive motor, in a pre-defined alignment on the insulating body.

**8 Claims, 4 Drawing Sheets**

(51) **Int. Cl.**  
**H02K 7/14** (2006.01)  
**H02K 29/08** (2006.01)



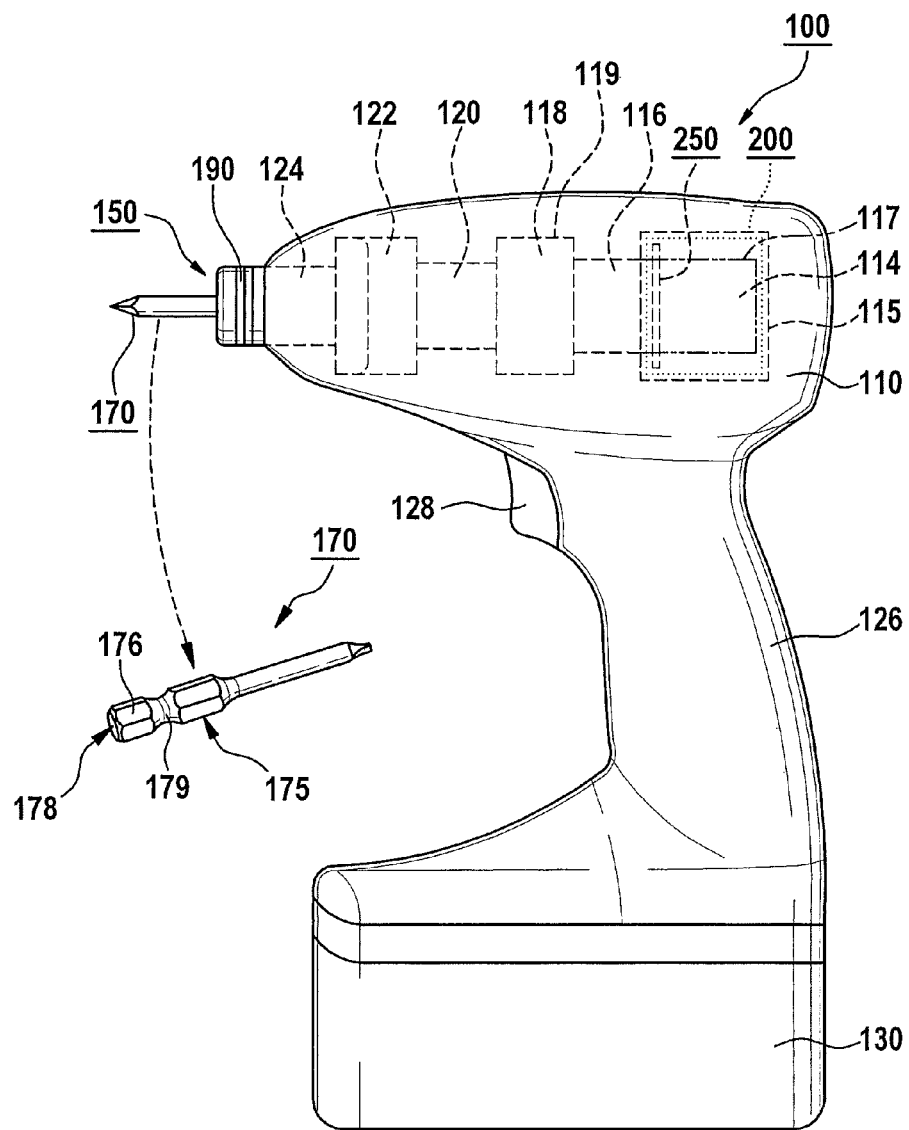
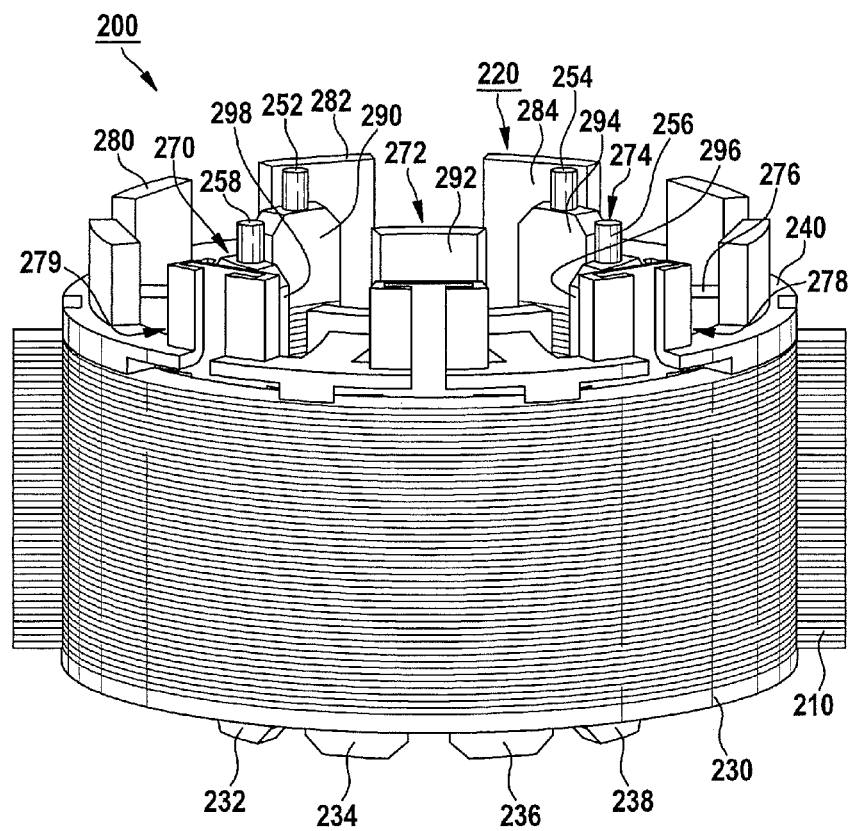
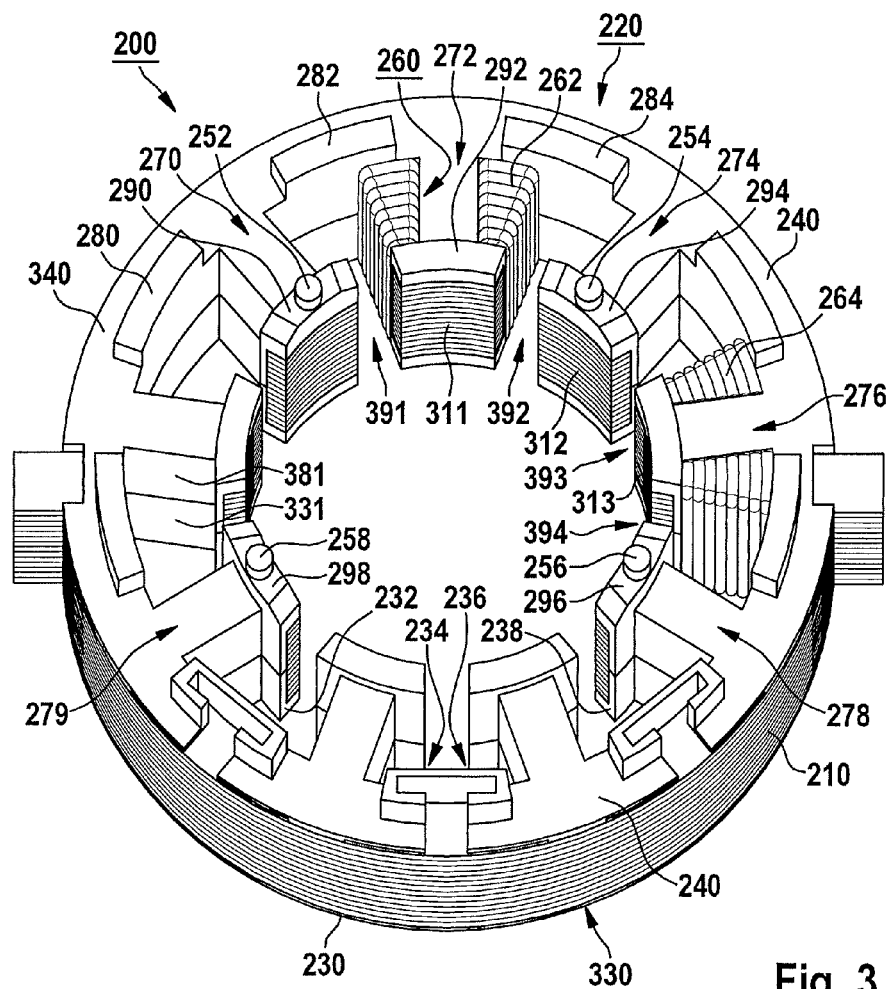


Fig. 1



**Fig. 2**



**Fig. 3**

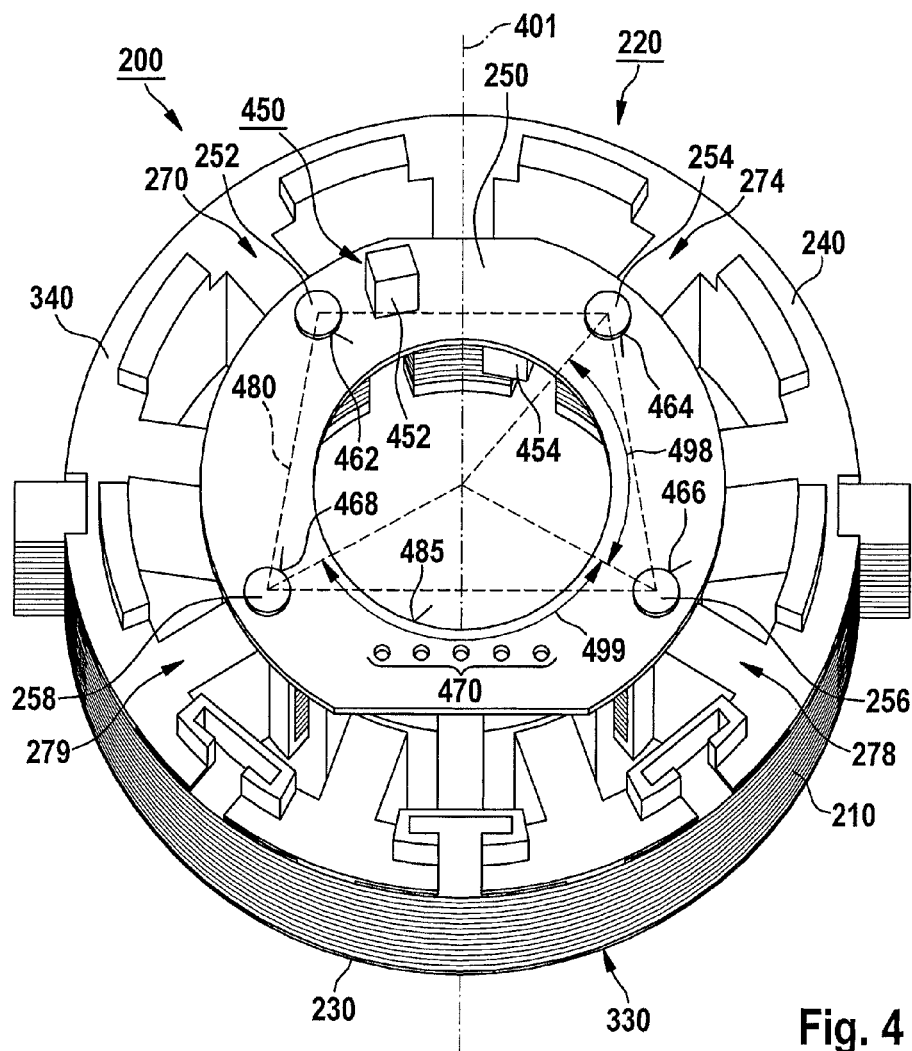


Fig. 4

## 1

## POWER TOOL

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates to a power tool having an electronically commutated drive motor to which stator components are assigned having a stator core equipped with an insulating body.

## 2. Description of the Related Art

Such a power tool having an electronically commutated drive motor and stator components assigned to it is known from the related art. In addition, a circuit board, on which Hall sensors are provided for detection of a magnetic field of a rotor, which is induced to rotate by the stator components during operation of the drive motor, is assigned to the drive motor of such a power tool, to thereby enable a determination of the rotational position of the rotor. The circuit board is mounted in a predefined position in or on the drive motor.

One disadvantage of the related art is that either a screw connection or a special receptacle is necessary for positioning the circuit board in or on the drive motor, and the receptacle must in turn be mounted and secured in or on the drive motor. This is, however, time consuming and cost intensive and lengthens, i.e., complicates the manufacture of such a power tool.

## BRIEF SUMMARY OF THE INVENTION

One object of the present invention is therefore to provide a novel power tool having an electronically commutated drive motor, so that an assigned circuit board may be positioned easily and quickly in or on the drive motor during its manufacture.

This problem is solved by a power tool having an electronically commutated drive motor to which stator components having a stator core equipped with an insulating body are assigned, a positioning unit being provided on the insulating body which is designed to permit positioning of a circuit board assigned to the drive motor in a predefined alignment on the insulating body.

The present invention thus makes it possible to provide a power tool having an electronically commutated drive motor in which positioning of an assigned circuit board in or on the drive motor is enabled by utilizing components with their manufacturing concepts which are already present and assigned to the stator components. This simplifies and accelerates the manufacture of the drive motor and the power tool and makes it less expensive accordingly.

The positioning unit is preferably designed to enable mounting of the circuit board on the insulating body.

The circuit board may thus be mounted reliably and securely on the stator components in a predefined alignment.

According to one specific embodiment, the circuit board is provided with at least one rotational direction sensor, which is situated in a predefined axial position in the drive motor due to the positioning of the circuit board on the insulating body.

The present invention thus makes it possible to provide a power tool, in which a precise alignment of an assigned rotational direction sensor in or on the drive motor is made possible in a simple manner.

The positioning unit preferably has at least two positioning elements which are situated in a predefined configuration on the insulating body.

A robust and stable positioning unit may thus be made available.

## 2

The insulating body and the positioning elements are preferably made of plastic in at least some areas, the positioning elements being integrally molded on the insulating body and/or designed in one piece with the insulating body.

An uncomplicated and inexpensive positioning unit may thus be made available.

At least two positioning receptacles for accommodating the at least two positioning elements are preferably formed on the circuit board.

This permits a rapid and accurately positioned alignment and configuration of the circuit board on the stator components.

The positioning elements are preferably designed in the form of pins, and the positioning receptacles are formed in the manner of positioning openings through which the positioning elements pass.

Inexpensive and robust positioning elements and receptacles may thus be made available.

According to one specific embodiment, the positioning elements are fused in at least some sections in the area of the positioning receptacles for mounting the circuit board on the insulating body, in particular by hot staking.

The present invention thus makes it possible to provide a power tool in which the circuit board may be mounted on the stator components in or on the drive motor in a stable and reliable manner.

The positioning elements are preferably situated asymmetrically on the insulating body with respect to a longitudinal axis of the stator components.

This permits a rapid and precise alignment of the circuit board on the insulating body during its assembly in or on the drive motor.

Four positioning elements are preferably provided and are situated in a trapezoidal pattern on the insulating body.

This permits a reliable and robust mounting of the circuit board on the insulating body.

In addition, the problem mentioned at the outset is also solved by an electronically commutated drive motor, in particular for a power tool, which is provided with stator components having a stator core equipped with an insulating body, a positioning unit being provided which is designed to permit positioning of a circuit board assigned to the drive motor in a predefined alignment on the insulating body.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic view of a power tool having an electronically commutated drive motor according to one specific embodiment.

FIG. 2 shows a perspective view of stator components assigned to the electronically commutated drive motor from FIG. 1, having an insulating body equipped with a positioning unit according to one specific embodiment.

FIG. 3 shows a perspective top view of the stator components from FIG. 2.

FIG. 4 shows a top view of the stator components from FIG. 3 having a circuit board mounted on the stator components.

## DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a power tool **100**, which is equipped with a tool receptacle **150** and has a housing **110** including a handle **126**. According to one specific embodiment, power tool **100** is mechanically and electrically connectable to a battery pack **130** for a cordless power supply.

3

Power tool **100** is designed as a cordless drill combo, for example. However, it is pointed out that the present invention is not restricted to cordless drill combos but instead may be applied to different power tools, e.g., a screwdriver, a drilling screwdriver, a percussion drill, a saw, a grinding machine, a milling machine, an electric lawnmower, etc., regardless of whether power tool **100** is mains-operable or cordless-operable using battery pack **130**.

An electric drive motor **114**, which receives power from battery pack **130**, a gear **118** and an optional striking mechanism **122** are situated in housing **110**. Drive motor **114** is actuable, for example, via a manual switch **128**, i.e., switchable on and off, and is preferably electronically controllable or adjustable, so that a reverse mode as well as specifications with regard to a desired rotational speed are implementable.

According to one specific embodiment, drive motor **114** is an electronically commutated drive motor, preferably a dc motor which has, for example, at least stator components and rotor components **200** and **117** plus at least one circuit board **250**. For example, stator components **200** form an external stator and are described further below in the context of FIGS. **2** and **3**, whereas any further description of rotor components **117** forming an internal rotor has been omitted for the purpose of simplicity and succinctness of the description. However, it should be pointed out that the description of a drive motor having an external stator and an internal rotor merely has an exemplary nature and is not to be understood as a restriction on the present invention, which may be used even with a drive motor having an internal stator and an external rotor. In addition, no description is given here of the functionality of the electronically commutated drive motor **114** for the sake of simplicity and succinctness of the description because those skilled in the art are adequately familiar with it.

Drive motor **114** is connected via an assigned motor shaft **116** to gear **118**, which converts a rotation of motor shaft **116** into a rotation of a drive member **120**, e.g., a drive shaft, which is provided between gear **118** and striking mechanism **122**. This conversion preferably takes place in such a way that drive member **120** rotates at an increased torque but a reduced rotational speed in relation to motor shaft **116**. Drive motor **114** is situated in a motor case **115**, for example, and gear **118** is situated in a gear case **119**, gear case **119** and motor case **115** being situated in housing **110**, for example.

Optional striking mechanism **122** which is connected to drive member **120** is a rotary striking mechanism, for example, which generates hammer-type rotary pulses of high intensity and transmits them to an output shaft **124**, e.g., an output spindle. An example of a striking mechanism with which striking mechanism **122** may be implemented is described in DE 20 2006 014 850 U1, to which reference is explicitly made here and the teachings of which are to be understood as being a part of the present description, so that a detailed description of optional striking mechanism **122** may be omitted here for the purpose of the succinctness of the description.

Tool receptacle **150**, which is provided to receive insertion tools having external polygonal couplings, for example, is provided on output shaft **124** and has a locking sleeve **190**, for example, for locking these insertion tools in an internal receptacle of tool receptacle **150**. Tool receptacle **150** is designed to receive an insertion tool **170** designed in the manner of a screwdriver bit, for example, having a shaft **176** including a coupling contour **175** in an axial end area **178**, which is formed by a polygonal cross section, in particular a hexagonal cross section of shaft **176** and an outer ring groove **179** provided on the shaft, e.g., according to DIN 3126-E6.3. Such a

4

screwdriver bit, which may be of the so-called hex-head type as an example, is sufficiently well known in the related art, so that a detailed description is omitted here for the purpose of the succinctness of the description.

However, it should be pointed out that the present invention is not restricted to a use of hex-head screwdriver bits, but instead other insertion tools may also be used, depending on the selected design of tool receptacle **150**, e.g., hex drills or so-called SDS quick insertion tools. In addition, it should be pointed out that the present invention is also not restricted to tool receptacles for holding insertion tools having external polygonal couplings but may also be used with tool receptacles for holding insertion tools having internal polygonal couplings and/or tool receptacles for holding insertion tools having external or internal polygonal couplings.

FIG. **2** shows stator components **200** of electronically commutated drive motor **114** of power tool **100** of FIG. **1**, which have a stator core **210**, which is equipped with an insulating body **220** as an example. Stator core **210** has, for example, multiple sheet metal plates stacked one above the other and forms together with insulating body **220** multiple stator poles, e.g., nine stator poles, only six of which are labeled using reference numerals **270**, **272**, **274**, **276**, **278**, **279** for the purpose of simplicity and clarity of the drawing. Insulating body **220** has as an example at least one first insulating body section **240** and one second insulating body section **230**, which are pushed onto the end areas of stator core **210** (from top to bottom in FIG. **2**) starting from these mutually axially opposed end areas. To simplify the description, first insulating body section **240** is therefore also referred to below as the “upper insulating body section” and second insulating body section **230** is referred to as the “lower insulating body section.”

However, it is pointed out that the two-part design of insulating body **220** having upper and lower insulating body sections **240** and **230** is only of an exemplary nature and is not to be understood as a restriction of the present invention. This may also be used with one-piece insulating bodies formed by plastic injection molding, for example, or multipart, e.g., three-part or four-part insulating bodies.

At least one and, for example, nine external axial extensions are formed on upper insulating body section **240**, only three of which are labeled using reference numerals **280**, **282**, **284** here for the purpose of simplicity and clarity of the drawing. These may help to align and fasten stator components **200** in motor case **115** of FIG. **1**, for example, during a manufacture of drive motor **114** of FIG. **1**.

In addition, at least one and, for example, nine internal axial extensions are formed on upper insulating body section **240**, only five of which are labeled using reference numerals **290**, **292**, **294**, **296**, **298** for the sake of simplicity and clarity of the drawing. Corresponding internal axial extensions may be provided on lower insulating body section **230** for this purpose, only four of these being labeled using reference numerals **232**, **234**, **236**, **238** for the sake of simplicity and clarity of the drawing. Internal axial extensions **290**, **292**, **294**, **296**, **298**, **232**, **234**, **236**, **238** help to secure an assigned motor winding (**260** in FIG. **3**) radially on stator poles **270**, **272**, **274**, **276**, **278**, **279**.

According to one specific embodiment, a positioning unit **252**, **254**, **256**, **258** is provided on insulating body **220**, designed at least to enable positioning of circuit board **250** of FIG. **1** in a predefined alignment on insulating body **220**, the circuit board being assigned to drive motor **114** of FIG. **1**. In addition, positioning unit **252**, **254**, **256**, **258** may be designed to also enable a mounting of circuit board **250** of FIG. **1** on insulating body **220**.

5

For the sake of illustration, positioning unit **252, 254, 256, 258** is formed on upper insulating body section **240** and has at least two and, for example, four positioning elements **252, 254, 256, 258**, which are situated in a predefined arrangement on insulating body **220**. This arrangement is asymmetrical with respect to a longitudinal axis of stator components **200**. Positioning elements **252, 254, 256, 258** are designed as pins in the example and are situated on inner axial extension **290, 294, 296** and **298**. Insulating body **220** and positioning elements **252, 254, 256, 258** are made of plastic in at least some areas here, so that positioning elements **252, 254, 256, 258** may be integrally molded on insulating body **220** and/or may be designed in one piece with the latter.

FIG. 3 shows stator components **200** of FIG. 2 for illustration of pin-shaped positioning elements **252, 254, 256, 258** of positioning unit **252, 254, 256, 258** formed on upper insulating body section **240** of insulating body **220** as an example. In addition, FIG. 3 shows as an example a motor winding **260**, which is provided on stator components **200** and is wound by any suitable winding method onto stator core **210**, which is provided with insulating body **220** and may have multiple interconnected individual coils. For example, only two individual coils are labeled using reference numerals **262, 264** for the sake of simplicity and clarity of the drawing, these coils being situated on stator poles **272** and **276** as an example. Insulating body **220** according to one specific embodiment is held on stator core **210** by motor winding **260**.

Stator core **210** has multiple T-shaped stator teeth, only three of which are labeled using reference numerals **311, 312, 313** for the sake of simplicity and clarity of the drawing, winding grooves for accommodating motor winding **260** or individual coils **262, 264** being formed between the stator teeth. Only four winding grooves are labeled using reference numerals **391, 392, 393, 394** here for the purpose of simplicity and clarity of the drawing. For insulation of these winding grooves **391, 392, 393, 394** in at least some sections, multiple column-type groove insulators are formed on the lower insulating body section **230** as an example, e.g., on an insulator plate **330**, one of which is labeled using reference numeral **331** as an example. Corresponding to this, multiple column-type groove insulators are formed on an annular supporting member **340** which is provided for support on stator core **210** on upper insulating body section **240** as an example, one of these groove insulators being labeled using reference numeral **381** as an example and also being provided for insulation of winding grooves **391, 392, 393, 394** in at least some sections.

Outer axial extensions **280, 282, 284** are formed on annular supporting member **340** as an example and are situated here in the area between adjacent stator poles. Outer axial extension **282**, for example, is situated in the area between stator poles **270** and **272**, outer axial extension **284** being situated in the area between stator poles **272** and **274**, etc. Inner axial extensions **290, 292, 294, 296, 298, 232, 234, 236, 238** are each situated on the radially opposite ends of stator poles **270, 272, 274, 276, 278** and **279** on so-called head sections of stator teeth **311, 312, 313**. As described with regard to FIG. 2 above, this configuration helps to radially support or secure motor winding **260** or individual coils **262, 264** on stator poles **270, 272, 274, 276, 278, 279** as illustrated, for example, on the basis of the radial support of individual coil **262** by inner axial extension **292** on stator tooth **311**.

FIG. 4 shows stator components **200** from FIGS. 2 and 3 with insulating body **220** on which circuit board **250** is positioned and mounted in a predefined alignment, as shown in FIG. 1 as an example, so that a representation of motor winding **260** from FIG. 3 has been omitted to simplify the drawing.

6

Circuit board **250** has at least one rotational direction sensor **454** as an example, which is situated in a predefined axial position in or on drive motor **114** of FIG. 1 as a result of the positioning of circuit board **250** on insulating body **220**. Rotational direction sensor **454** is designed in the manner of a Hall sensor, for example, and may be used to determine the rotational position of rotor components **117** of FIG. 1. Circuit board **250** may have an electronic circuit **450** having additional electronic components **452**, which are also designed for motor control, for example, as well as a plurality of connecting elements **470** for electrical contacting of electronic components **450**, of rotational direction sensor **454** and of motor winding **260** of FIG. 3.

According to one specific embodiment, circuit board **250** has an approximately central opening **486** for accommodating a rotor shaft of rotor components **117** from FIG. 1, e.g., motor shaft **116** from FIG. 1 as well as at least two and, for example, four positioning receptacles **462, 464, 466, 468**. These are formed in the manner of positioning openings as an example to enable an accommodation or reach-through of pin-shaped positioning elements **252, 254, 256** and **258** of insulating body **220**. In addition, positioning elements **252, 254, 256, 258** are fused in at least some sections in the area of positioning receptacles **462, 464, 466, 468** for mounting circuit board **250** on insulating body **220**, e.g., by hot staking. However, it should be pointed out that alternative mounting methods, e.g., adhesive bonding or latching, are also possible within the context of the present invention.

As described in conjunction with FIG. 2 above, four pin-shaped positioning elements **252, 254, 256, 258** which are situated asymmetrically around a longitudinal axis **401** of stator components **200** are provided as an example, the asymmetrical configuration being achieved by a trapezoidal distribution on insulating body **220**, for example, as indicated by a trapezoid **480** shown with broken lines. However, it should be pointed out that the trapezoidal configuration of positioning elements **252, 254, 256, 258** on insulating body **220** is only of an exemplary nature and is not to be understood as restricting the present invention to such an asymmetrical configuration. Instead an asymmetrical configuration may be achieved easily by situating the positioning elements **252, 254, 256, 258** on insulating body **220** with respect to the longitudinal axis **401** of stator components **200** and of insulating body **220** in such a way that an angle **498** between a first and a second positioning element **254, 256** is not equal to an angle **499** between the second and third positioning elements **258**.

What is claimed is:

1. A power tool, comprising:

- an electronically commutated drive motor;
- stator components assigned to the electronically commutated drive motor, wherein the stator components include a stator core equipped with an insulating body;
- a circuit board assigned to the drive motor; and
- a positioning unit provided on the insulating body and configured to enable a positioning of the circuit board in a predefined alignment on the insulating body, wherein the positioning unit is configured to enable a mounting of the circuit board on the insulating body, wherein the positioning unit has at least two positioning elements which are situated in a predefined configuration on the insulating body, wherein at least two positioning receptacles for accommodating the at least two positioning elements are formed on the circuit board,
- wherein the positioning elements in the area of the positioning receptacles for mounting the circuit board on the insulating body are fused in at least some sections,



7

wherein the positioning elements are situated asymmetrically on the insulating body with respect to a longitudinal axis of the stator components.

2. The power tool as recited in claim 1, wherein the circuit board is provided with at least one rotational direction sensor which is situated on a predefined axial position in the drive motor due to the positioning of the circuit board on the insulating body.

3. The power tool as recited in claim 1, wherein the insulating body and the positioning elements are each at least partially made of plastic, the positioning elements being at least one of (i) integrally molded on the insulating body and (ii) configured in one piece with the insulating body.

4. The power tool as recited in claim 1, wherein the positioning elements are configured in the form of pins, and the positioning receptacles are configured as positioning openings through which the positioning elements pass.

5. The power tool as recited in claim 1, wherein four positioning elements are provided and situated in a trapezoidal pattern on the insulating body.

6. A drive system for a power tool, comprising:  
an electronically commutated drive motor;  
stator components assigned to the electronically commutated drive motor, wherein the stator components include a stator core equipped with an insulating body;

8

a circuit board assigned to the drive motor; and  
a positioning unit provided on the insulating body and configured to enable a positioning of the circuit board in a predefined alignment on the insulating body,

wherein the positioning unit is configured to enable a mounting of the circuit board on the insulating body, wherein the positioning unit has at least two positioning elements which are situated in a predefined configuration on the insulating body,

wherein at least two positioning receptacles for accommodating the at least two positioning elements are formed on the circuit board,

wherein the positioning elements in the area of the positioning receptacles for mounting the circuit board on the insulating body are fused in at least some sections, wherein the positioning elements are situated asymmetrically on the insulating body with respect to a longitudinal axis of the stator components.

7. The power tool as recited in claim 1, wherein the positioning elements are fused in at least some sections in the area of the positioning receptacles by hot staking.

8. The drive system as recited in claim 6, wherein the positioning elements are fused in at least some sections in the area of the positioning receptacles by hot staking.

\* \* \* \* \*